AMENDMENTS TO THE SPECIFICATION AND ABSTRACT:

Please delete the heading beginning at page 1, line 1 of the original specification:

~~DESCRIPTION~~

Please replace the paragraph beginning at page 2, line 19, with the following rewritten paragraph:

As a method for connecting an IC chip to a liquid crystal display (second prior art), as disclosed in Japanese Examined Patent Publication No. 62-6652 shown in Fig. 16A and Fig.16B, there is generally known a semiconductor chip connection structure in which an anisotropic conductive film 80 is employed, and by peeling off an anisotropic conducting adhesive layer 81 constituted by adding conductive minute segments 82 into an insulating resin 83 from a separator 85 and applying the film onto a board or the glass of a liquid crystal display 84 and thermocompression-bonding an IC chip 86, the anisotropic conducting adhesive layer 81 is interposed between a lower surface of the IC chip 86 and the board 84 except for spaces under the Au bump 87.

Please replace the heading beginning at page 6, line 20, with the following rewritten heading:

--SUMMARY OF THE INVENTION--.

Please replace the heading beginning at page 47, line 2, with the following rewritten heading:

--DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS--.

Please replace the paragraphs beginning at page 47, line 9, and ending at page 92, line 20, with the following rewritten paragraphs:

(First Embodiment)

A method and apparatus for mounting an IC chip ~~on~~ onto a circuit board as an example of an electronic component mounting method and apparatus, and an electronic component unit or module such as a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to a first embodiment of the present invention will be described below with reference to Fig. 1A through Fig. 14.

Reference is first made to the method for mounting an IC chip ~~on~~ onto a circuit board according to the first embodiment of the present invention with reference to Figs. 1A through Fig. 4C and Figs. 6A through 6F.

A bump (protruding electrode) 3 is formed on an Al pad electrode 2 of an IC chip 1, that serves as one example of ~~the~~ an electronic component, of Fig. 1A by a wire bonding device through ~~the~~ an operation shown in Fig. 3A through Fig. 3F. That is, a ball 96 is formed at ~~the~~ a lower end of a wire 95 protruding from a capillary 93 that serves as a holder in Fig. 3A, and the capillary 93 that is holding the wire 95 is lowered in Fig. 3B so as to bond the ball 96 to the electrode 2 of the chip 1, roughly forming ~~the~~ a shape of the bump 3. By making the capillary 93 start to move up while downwardly feeding the wire 95 in Fig. 3C, moving the capillary 93 in an approximately rectangle-shaped loop 99 as shown in Fig. 3D to form a curved portion 98 on the bump 3 as shown in Fig. 3E, and ~~tear~~ tearing ~~off~~ the wire, the bump 3 as shown in Fig. 1B and Fig. 3F is formed. Otherwise, by clamping the wire 95 by the capillary 93 and pulling the capillary 93 ~~upward~~ upwardly in Fig. 3B, the metal wire of, for example, ~~a~~ gold ~~wire~~ (gold line) 95 (note that ~~the~~ examples of the metal wire include those made of zinc, aluminum, copper, or an alloy obtained by incorporating a trace element into these metals, and the gold wire (gold line) will hereinafter be referred to as a representative example in the following embodiments) may be torn ~~off~~ so as to form a bump 3 of a shape as shown in Fig. 3G. A state in which the bump 3 is thus formed on each electrode 2 of the chip 1 is shown in Fig. 1B.

Next, in the present embodiment, an anisotropic conductive film (ACF) sheet 10 is interposed, as one example of ~~the~~ an anisotropic conductive layer, between a circuit board 4 and the IC chip 1 when the IC chip ~~1~~ with the electrodes 2, on each of which the bump 3 is formed, is to be mounted ~~on a~~ onto the circuit board 4. This anisotropic conductive film sheet 10 contains an inorganic filler 6f, of a mean diameter smaller than ~~the~~ a mean diameter of conductive particles 10a in ~~a solid resin~~ the conductive film sheet, that has an insulative thermosetting property ~~and constitutes the anisotropic conductive film sheet 10~~. For example, as shown in Fig. 36, assuming that the mean diameter of the conductive particles 10a is set to 0.5 μm smaller than ~~the~~ a mean diameter of 1.0 μm of ~~the~~ conductive particles 10a of ~~the~~ a conventional ACF, then the mean diameter of the particles of the inorganic filler 6f is set to about 3 to 5 μm. As the conductive particles 10a contained in the anisotropic conductive

film sheet 10, nickel powder plated with gold is employed. With this arrangement, a connection resistance between ~~the~~ electrode 5, located on the board ~~side~~ 4, and the bump 3 located on the IC chip ~~side~~ can be reduced, more satisfactorily.

More preferably, by providing the conductive particles 10a ~~by~~ as conductive particles ~~10a~~ whose conductive particle bodies 10a-1 are outwardly coated with an insulating layer 10a-2, and setting ~~the~~ an amount of the conductive particles 10a more than double that ~~of the~~ generally employed in an anisotropic conductive film, the conductive particles 10a are held by the bump 3 with a certain probability. This enables ~~the~~ an improvement ~~in~~ with regard to tolerance ~~to~~ of a thermal impact due to swelling caused by absorbed moisture and ~~the~~ subsequent reflow.

If the conductive ~~particles 10a~~ particle bodies 10a-1 thus coated with ~~the~~ insulation ~~coating~~ layer 10a-2 is placed between the bump 3 and the board electrode 5, then the ~~very thin~~ insulation ~~coating portion~~ layer 10a-2 ~~located outside the conductive particles 10a~~ is abraded away to expose the conductive particle bodies 10a-1, which ~~take the effect of their abilities~~ then perform their function of conduction. Accordingly, the insulation ~~coating portion 10a-1~~ layer 10a-2 is not abraded away ~~in the~~ at a location ~~portion~~ that is not placed between the bump 3 and the electrode 5, and therefore, ~~the abilities~~ performance of conduction of the conductive particle bodies 10a-1 do not take effect here. Accordingly, a short circuit between the electrode 5 and the electrode 3 is ~~hard~~ difficult to occur in ~~the~~ a surface direction. Moreover, when a stud bump is employed, it is usually difficult to place the conductive particles 10a between the electrode 5 and the bump 3 since its top portion has a small area. Therefore, it is required to incorporate a large amount of conductive particles 10a. However, ~~if~~ in doing so, the conductive particles sometimes come into contact with each other, thereby possibly causing a short circuit between the electrodes ~~3~~ 2 and 5. Therefore, it is preferable to employ ~~insulating~~ conductive ~~particles~~ particle bodies that are coated with an insulation layer ~~coating~~. Moreover, ~~the~~ a reason why ~~the~~ a reflow characteristic and ~~so on~~ the like are improved is because, when ~~the~~ an anisotropic conductive film forming adhesive (or anisotropic conductive film sheet) swells in a Z-direction (~~the~~ a direction of thickness of the anisotropic conductive film sheet) caused by ~~the~~ swelling due to ~~the~~ factors of temperature and humidity, the conductive particles 10a swell more than that, allowing ~~the~~ a connection to be maintained. Therefore, it is preferable to

employ Au-Ni particle bodies having a repulsion power and coated with plastic ~~particles~~, or the like, ~~having a repulsion power~~ for the conductive particles 10a.

Next, as shown in Fig. 1D, ~~an~~ the anisotropic conductive film sheet 10, which is cut into a size slightly larger than ~~the~~ a size of the chip 1 and ~~mixed with an~~ includes inorganic filler 6f, is arranged on the electrodes 5 of the circuit board 4 of Fig. 1C, and the anisotropic conductive film sheet 10 is adhered ~~stuck~~ to the board 4 with a pressure force of, for example, about 5 to 10 kgf/cm2 by ~~means~~ virtue of a ~~sticking~~ pressing tool 7 heated to, for example, 80 to 120°C. Subsequently, by peeling off a separator 10g, removably arranged on the ~~sticking~~ pressing tool side of the anisotropic conductive film sheet 10, a preparation process of the board 4 is completed. This separator 10g is to prevent the anisotropic conductive film sheet 10, that contains a solid or semi-solid thermosetting resin mixed with the inorganic filler 6f, from adhering to the ~~sticking~~ pressing tool 7. In this case, as shown in Fig. 1G, which ~~that~~ is an enlarged view of ~~a~~ portion G of Fig. 1F, the anisotropic conductive film sheet 10 is preferably provided by mixing an insulating resin 6m with ~~an~~ inorganic filler 6f of ceramics of spherical or pulverized silica, alumina or the like, having ~~of~~ a mean diameter smaller than ~~the~~ a mean diameter of the conductive particles 10a in dispersion, flattening this mixture by ~~the~~ a doctor blade method or the like, and vaporizing ~~the~~ a solvent component for solidification. The conductive film sheet 10 ~~and~~ preferably ~~have~~ has a heat resistance ~~to the extent of~~ sufficient for tolerating a high temperature in ~~the~~ a subsequent reflow process (for example, a heat resistance capable of tolerating a temperature of 240°C for ten seconds). The insulating resin 6m can be ~~provided by~~, for example, an insulative thermosetting resin (for example, epoxy resin, phenol resin, and polyimide) or an insulative thermoplastic resin (for example, polyphenylene sulfide (PPS), polycarbonate, and modified polyphenylene oxide (PPO)), a mixture of an insulative thermosetting resin with an insulative thermoplastic resin, or the like. In this case, description will be continued with the insulative thermosetting resin taken as a representative example. This insulative thermosetting resin 6m generally has a glass transition point of about 120 to 200°C. When only a thermoplastic resin is ~~only~~ employed, the resin is once initially softened by heating ~~at the beginning~~ and then hardened by being naturally cooled with the heating stopped. When a mixture of an insulative thermosetting resin with an insulative thermoplastic resin is employed, ~~the~~ this resin mixture is

hardened by being heated similarly to ~~the~~ a case of only ~~the~~ using a thermosetting resin ~~is employed~~ because the thermosetting resin functions predominantly.

Next, as shown in Fig. 1E and Fig. 1F, in an electronic component mounting apparatus 600 shown in Fig. 20, the chip 1 on which the bumps 3 are formed through the aforementioned process is sucked, and held, from a tray 602 by a heated bonding tool 8 located at ~~the~~ a tip of a component holding member 601, and the IC chip 1 is pressed against the board 4 via an anisotropic conductive film sheet 10 while being aligned in position with the electrodes 5 of the board 4 corresponding to the electrodes 2 of the IC chip 1, with the board 4 having been prepared through the aforementioned preceding process and mounted on a stage 9. This positional alignment is performed by a well-known position recognizing operation. For example, as shown in Fig. 21C, a positional recognition mark(s) 605 or a lead(s) or a land pattern(s) formed on the board 4 is recognized by a board recognizing camera 604 of the electronic component mounting apparatus 600. As shown in Fig. 21D, ~~the~~ a position of the board 4 is recognized by recognizing ~~the~~ an XY coordinate position of the board in ~~the~~ orthogonal XY directions on the stage 9 ~~of the board 4~~ and ~~the~~ a rotational position of the board relative to ~~the~~ an origin of ~~the~~ an XY coordinate system on ~~the~~ a basis of an image 606 obtained by the camera 604. On the other hand, a mark(s) 608 or a circuit pattern for recognizing ~~the~~ a position of the IC chip 1, sucked and held by the bonding tool 8, is recognized by an IC chip position recognizing camera 603 as shown in Fig. 21A, and the position of the IC chip 1 is recognized by recognizing ~~the~~ an XY coordinate position of the IC chip in the orthogonal XY directions ~~of the IC chip 1~~ and ~~the~~ a rotational position of the chip relative to the origin of the XY coordinate system on ~~the~~ a basis of an image 607 obtained by the camera 603 as shown in Fig. 21B. Then, the bonding tool 8 or the stage 9 is moved, on ~~the~~ a basis of ~~the~~ position recognition results of the board 4 and the IC chip 1, to perform positional alignment so that the electrodes 2 of the IC chip 1 are positioned on the corresponding electrodes 5 of the board 4, and thereafter, the IC chip 1 is pressed against the board 4 by ~~the~~ heated bonding tool 8. At this time, the bump 3 is pressed against the electrode 5 of the board 4 in a manner that a head portion 3a of the bump 3 is deformed as shown in Fig. 4B and Fig. 4C. At this time, ~~also in this embodiment similar to the first embodiment~~ as shown in Fig. 2A and Fig. 2B, the inorganic filler 6f in the thermosetting resin 6m is forced outwardly of the bump 3 ~~by~~ because of the ~~pointed~~ bump 3 ~~that enters~~ entering the thermosetting resin 6m at ~~the~~ a beginning of ~~the~~

bonding. Moreover, as ~~also in this embodiment similar to the first embodiment~~ shown in Fig. 2C, there is produced ~~the~~ an effect of reducing ~~the~~ a connection resistance value by ~~the~~ an arrangement in that the inorganic filler 6f does not enter ~~the~~ a space between the bump 3 and the board electrode 5 due to this outward ~~extruding~~ forcing action. At this time, even if a certain amount of inorganic filler 6f enters the space between the bump 3 and the board electrode 5, there is no problem ~~by virtue of the arrangement that~~ of the bump 3 ~~is~~ not being brought ~~in~~ into direct contact with the board electrode 5. At this time, a load is applied, which differs ~~while differing~~ depending on ~~the~~ an outside diameter of the bump 3, so that ~~the~~ a folded portion of the head 3a may be deformed without fail as shown in Fig. 4C. At this time, when the conductive particles 10a in the anisotropic conductive film sheet 10 are ~~is provided by~~ resin balls plated with a metal as shown in Fig. 6E, the conductive particles 10a are required to be deformed. When the conductive particles 10a in the anisotropic conductive film sheet 10 are metal particles of nickel or the like, it is required to apply a load to ~~the~~ an extent that the particles get stuck in the bump 3 and the electrode 5 located on the board 4 ~~side~~ as shown in Fig. 6D. This load is required to be at least 20 ~~(~~gf per bump~~) at the minimum~~. That is, ~~the~~ a resistance value becomes excessively increased to a resistance value of at least 100 mmΩ/bump ~~or higher~~ when the load is smaller than 20 ~~(~~gf per bump~~)~~, according to ~~the~~ a graph ~~of~~ showing a ~~relation~~ relationship between the resistance value and the load in ~~the~~ a case of ~~the~~ a bump ~~of~~ having an outside diameter of 80 μm as shown in Fig. 17, thus resulting in practical problems, and therefore, a load of not smaller than 20 ~~(~~gf per bump~~)~~ is preferable~~, as shown in Fig. 17~~. Fig. 18 is a graph showing a region of high reliability based on a ~~relation~~ relationship between bumps ~~of~~ having outside diameters of 80 μm and 40 μm and a minimum load. According to this graph, it is presumed that ~~the~~ a bump ~~of~~ having an outside diameter of not smaller than 40 μm is preferably loaded with a minimum load of not smaller than 25 ~~(~~gf per bump~~)~~, and ~~the~~ reliability is high when the minimum load is not smaller than about 20 ~~(~~gf per bump~~)~~ in ~~the~~ a case of ~~the~~ a bump ~~of~~ having an outside diameter smaller than 40 μm. It is also presumed that, in the future when ~~the~~ a bump outside diameter is reduced to 40 μm or less with a reduction in lead pitch ~~in the future~~, ~~the~~ a load tends to reduce in proportion to the second power of ~~the~~ a projected area of the bump depending on the projected area of the bump. Therefore, the minimum load applied ~~to the bump 3 side~~ via the IC chip 1 is preferably at least 20 ~~(~~gf per bump~~) at the minimum~~. ~~The~~ An upper limit of the load applied ~~to the bump 3 side~~ via the IC chip

1 is set to ~~the~~ an extent that none of the IC chip 1, the bump 3, the circuit board 4, and so on is damaged. According to circumstances, a maximum load may sometimes exceed 100 ~~(~~gf per bump~~)~~ or 150 ~~(~~gf per bump~~)~~. At this time, if an inorganic filler 6f whose mean diameter is smaller than the mean diameter of the conductive particles is employed, there can be produced ~~the~~ an effect of increasing ~~the~~ an elastic modulus of the thermosetting resin 6m and reducing ~~the~~ a coefficient of thermal expansion thereof.

It is to be noted that ~~the~~ reference numeral 10s in the figure denotes a resin resulting from the thermosetting insulating resin 6m that has been melted by ~~the~~ heat of the bonding tool 8 and thereafter thermally hardened ~~in~~ into the anisotropic conductive film sheet 10.

It is also acceptable to perform the process of aligning in position ~~the IC chip 1 on~~ the electrodes 2, on ~~of~~ which the bumps 3 have been formed through the aforementioned preceding process ~~by the bonding tool 8 heated by a built-in heater 8a such as a ceramic heater or a pulse heater~~, with the electrodes 5 of the board 4 ~~corresponding to the electrodes 2 of the IC chip 1~~ as shown in Fig. 1E, with the board 4 being prepared ~~at~~ by the preceding process, and the process of performing pressure bonding as shown in Fig. 1F after ~~the~~ positional alignment by ~~means~~ use of one positional alignment and pressure bonding apparatus, for example, the position aligning and pressure bonding apparatus of Fig. 1E. However, it is also acceptable to perform the positional alignment process and the pressure bonding process by separate units, for example, ~~the~~ a positional alignment device of Fig. 5B and ~~the~~ a bonding device of Fig. 5C, respectively, in order to improve ~~the~~ productivity by concurrently performing ~~the~~ positional alignment work and ~~the~~ pressure bonding work when continuously manufacturing, for example, ~~a lot of~~ many boards. Fig. 5C shows two bonding devices 8 provided for ~~the~~ a purpose of improving ~~the~~ productivity, by which two portions of one circuit board 4 can be concurrently subjected to pressure bonding.

In each of the aforementioned and undermentioned embodiments, the circuit board 4 is ~~provided by~~ a multilayer ceramic board, a glass fabric laminate epoxy board (glass epoxy board), an aramid unwoven fabric board, a glass fabric laminate polyimide resin board, an FPC (flexible printed circuit), or an aramid unwoven fabric epoxy board (for example, a resin multilayer board sold with a registered trademark of "ALIVH" and produced by Matsushita Electric Industrial Co., Ltd.), or the like.

These boards 4 ~~do~~ are not always ~~have a complete plane~~ planar since warps and undulations are generated due to thermal history, cutting, and processing. Accordingly, as shown in Fig. 5A and Fig. 5B, by locally applying heat and load to ~~the~~ circuit board 4 via ~~the~~ IC chip 1 from ~~the~~ a bonding tool ~~8~~ side toward ~~the~~ stage 9 side by ~~means~~ virtue of ~~the~~ bonding tool 8 and ~~the~~ stage 9, each of which ~~the~~ has its parallelism ~~is~~ controlled ~~so that the parallelism is adjusted~~ to, for example, about at most 10 μm or less, ~~the warp~~ warpage of the circuit board 4 ~~in the~~ at an applied portion is corrected.

~~The~~ IC chip 1 ~~is~~ can be warped so as to be concave about ~~the~~ a center of ~~the~~ an active surface. By pressurizing ~~the~~ such IC chip with a heavy load of not smaller than 20 gf per bump at ~~the~~ a time of bonding, ~~the~~ warps and undulations of both the board 4 and the IC chip 1 can be corrected. ~~The warp~~ Warpage of the IC chip 1 is generated by an internal stress caused when a thin film is formed on Is ~~in~~ while forming the IC chip 1. ~~The quantity~~ Quantity of deformation of ~~the~~ each bump 3 is about 10 to 25 μm, which becomes tolerated by each bump ~~3~~, which adapts itself with ~~the~~ deformation of the bump ~~3~~ to ~~the~~ an influence of ~~the~~ an undulation that appears on ~~the~~ a surface of ~~from the~~ an inner layer copper foil originally ~~owned by the~~ on a board of this grade.

Thus, ~~a~~ heat of, for example, 140 to 230°C is applied to the anisotropic conductive film sheet 10 located between the IC chip 1 and the circuit board 4 for, for example, about several seconds to 20 seconds in a state in which ~~the warp~~ warpage of the circuit board 4 is corrected, and this anisotropic conductive film sheet 10 is hardened. At this time, the thermosetting resin 6m, which constitutes part of the anisotropic conductive film sheet 10, flows first and encapsulates the IC chip 1 up to ~~the~~ an edge of the IC chip 1. Moreover, the resin, which is naturally initially softened ~~at the beginning~~ when heated, generates ~~a~~ fluidity of a flow to the edge as described above. By making ~~the~~ a volume of the thermosetting resin 6m greater than ~~the~~ a volume of ~~the~~ a space between the IC chip 1 and the circuit board 4, the resin flows and leaks out of this space, allowing ~~the~~ an encapsulation effect to be produced. Subsequently, the heated bonding tool 8 is moved up, by which ~~the~~ a heating source disappears to rapidly reduce ~~the~~ temperatures of the IC chip 1 and the anisotropic conductive film sheet 10. The anisotropic conductive film sheet 10 looses its fluidity, and as shown in Fig. 1F and Fig. 4C, the IC chip 1 is fixed onto the circuit board 4 with the resin 10s that is ~~constituting~~ the anisotropic conductive film sheet 10 after being softened and then hardened. Moreover, if the circuit

board 4 ~~side~~ is heated by a heater 9a of the stage 9 or the like, ~~the~~ a temperature of the bonding tool 8 can further be reduced.

With this arrangement, a thermosetting resin mixed with an inorganic filler of a mean particle diameter smaller than the mean diameter of the conductive particles 10a can be used for the anisotropic conductive film sheet 10. Furthermore, by using nickel powder plated with gold as the conductive particles 10a contained in the anisotropic conductive film sheet 10, ~~the~~ a connection resistance value can be reduced, more preferably.

According to the first embodiment, by mixing the inorganic filler 6f, that has a mean particle diameter smaller than the mean diameter of the conductive particles 10a, ~~as the inorganic filler 6f to be mixed~~ with the thermosetting resin 6m, ~~the~~ reliability can further be improved without hindering ~~the~~ operation of the conductive particles 10a. That is, the conductive particles 10a are placed between the bump 3 and the electrode 5 of the board 4. At this time, even if the inorganic filler 6f is concurrently placed between ~~them~~ the bump and electrode, ~~the~~ conductivity is not hindered since the mean particle diameter of the inorganic filler 6f is smaller than the mean diameter of the conductive particles 10a. Furthermore, the elastic modulus of the thermosetting resin 6m is increased and the coefficient of thermal expansion thereof is reduced, thereby improving ~~the~~ reliability of bonding of the IC chip 1 to the board 4.

(Second Embodiment)

A method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted ~~on~~ onto the board by the mounting method, according to a second embodiment of the present invention will be described next.

This second embodiment is made more preferable than the first embodiment by setting ~~the~~ a ratio of ~~mixture of~~ the inorganic filler 6f, in ~~to be mixed with~~ the anisotropic conductive film sheet 10 that contains ~~a~~ an insulating thermosetting resin, to ~~5 to 90 wt% of~~ the insulative thermosetting resin ~~of, for example,~~ to 5 to 90 wt% of the insulative thermosetting ~~epoxy~~ resin ~~6m~~. When the ratio is lower than 5 wt%, the ~~mixture~~ presence of the inorganic filler 6f is meaningless. When the ratio exceeds 90 wt%, ~~the~~ adhesive strength is extremely reduced, and it is difficult to form a sheet, leading

to a disadvantage. As an example, from ~~the~~ a point of view of maintaining high reliability, it is preferable to set the ratio to 20 to 40 wt% in ~~the~~ a case of a resin board, and to 40 to 70 wt% in ~~the~~ a case of a ceramic board. In ~~the~~ a case of a glass epoxy board, ~~the~~ a coefficient of linear expansion of ~~the~~ a sheet encapsulant can be considerably reduced at a ratio of about 20 wt%, thereby producing an effect on the ~~resin~~ glass epoxy board. The ratio is set to about half ~~the~~ a percentage by weight in terms of volume percentage, or in ~~the~~ proportions of 1 part epoxy resin to about 2 parts silica in terms of specific gravity. In ~~the~~ a normal case, the ratio ~~of mixture~~ of this inorganic filler ~~6f~~ to the insulating thermosetting resin is determined by ~~the~~ manufacturing conditions in forming the thermosetting resin ~~6m~~ into a sheet, by ~~the~~ an elastic modulus of ~~the~~ board 4, and finally by ~~the~~ a result of a reliability test.

By ~~mixing~~ providing the inorganic filler 6f at the aforementioned ratio to the ~~of mixture with the anisotropic conductive film sheet 10 that contains a~~ thermosetting resin 6m, the elastic modulus of the thermosetting resin 6m of the anisotropic conductive film sheet 10 can be increased, and ~~the~~ reliability of bonding of ~~the~~ IC chip 1 to the board 4 can be improved by reducing the coefficient of thermal expansion. Moreover, the ratio of ~~mixture of~~ the inorganic filler 6f to the thermosetting resin can be determined so that ~~the~~ a material constant of the thermosetting resin 6m, i.e., ~~the~~ an elastic modulus and ~~the~~ a coefficient of linear expansion are optimized according to ~~the~~ material of the board 4. It is to be noted that the coefficient of linear expansion tends to be reduced although the elastic modulus is increased as the ratio ~~of mixture~~ of the inorganic filler 6f to the thermosetting resin 6m is increased.

The first embodiment and the second embodiment have ~~the~~ advantages in that the ~~employed~~ anisotropic conductive film sheet 10, which is not liquid but solid, is easy to handle and is able to be formed of polymer since no liquid component exists, thereby allowing an anisotropic conductive film sheet having ~~the objective one with~~ a high glass transition point to be easily formed.

With reference to Fig. 1A through Fig. 1G, Fig. 2A through Fig. 2C, ~~and~~ Fig. 6A through Fig. 6E, and Fig. 7A through Fig. 7F described later, ~~the~~ formation of ~~the~~ anisotropic conductive film sheet 10 that contains ~~the~~ thermosetting resin as one example of the anisotropic conductive layer, or the anisotropic conductive film forming thermosetting adhesive 6b on the circuit board 4, ~~side~~ has been described. However, without being limited to this, the sheet or adhesive may be formed on the IC chip 1 ~~side~~ and thereafter bonded to the board 4 as shown in Fig. 14A or Fig. 14B. In the case

of, in particular, ~~the~~ an anisotropic conductive film sheet 10 that contains ~~the~~ thermosetting resin, it is acceptable to adhere ~~stick~~ the anisotropic conductive film sheet 10 to the IC chip 1 along ~~the~~ a configuration of ~~the~~ bumps 3 by pressing the IC chip 1 held by a holding member 200, such as a suction nozzle, against an elastic body 117, such as rubber on a stage 201, together with a separator 6a removably arranged on the circuit board side of the anisotropic conductive film sheet 10.

(Third Embodiment)

A method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted ~~on~~ onto the board by the mounting method, according to a third embodiment of the present invention will be described next with reference to Fig. 6A through Fig. 6C and Fig. 7A through Fig. 7F.

According to this third embodiment, instead of adhering ~~sticking~~ the anisotropic conductive film sheet 10 that contains a thermosetting resin onto ~~the~~ board 4 as in the first embodiment, an anisotropic conductive film forming thermosetting adhesive 6b that has a liquid form, and serves as one example of the anisotropic conductive layer, is applied, ~~or~~ printed or transferred onto the circuit board 4 by a dispenser 502 or the like as shown in Fig. 6A and Figs. 7A and 7D, and thereafter solidified into a semi-solid state, or ~~the~~ a state of ~~the~~ a so-called B stage. Subsequently, ~~the~~ IC chip 1 is mounted ~~on~~ onto the board 4 similarly to the first or second embodiment.

In detail, as shown in Fig. 6A, the anisotropic conductive film forming thermosetting adhesive 6b in ~~the~~ liquid form is applied, ~~or~~ printed or transferred onto the circuit board 4 by the dispenser 502 or the like, which can be moved in two directions that are orthogonal to a ~~on the~~ board surface, and ~~the~~ a discharge rate of ~~which~~ the thermosetting adhesive is controlled with ~~an~~ air pressure as shown in Fig. 7A. Next, the adhesive is solidified into a semi-solid state, or the state of the so-called B stage as shown in Fig. 6C, by applying ~~through uniforming with~~ heat and pressure via ~~applied by~~ a tool 78 that has a built-in heater 78a as shown in Fig. 6B.

Otherwise, in ~~the~~ a case where the anisotropic conductive film forming thermosetting adhesive 6b in ~~the~~ liquid form has a low viscosity, the liquid thermosetting adhesive 6b is applied to a specified position on ~~the~~ board 4 by ~~means~~ use of the dispenser 502 as shown in Fig. 7A, and thereafter, the

thermosetting adhesive 6b naturally spreads on the board, since its viscosity is low, and enters into a state as shown in Fig. 7B. Subsequently, by putting the board 4 into a furnace 503 by ~~means~~ use of a conveying unit 505, ~~like a conveyer~~ as shown in Fig. 7C, and hardening the liquid thermosetting adhesive 6b ~~of the applied insulating resin by~~ via a heater 504 of the furnace 503, the adhesive is solidified into a semi-solid state, i.e., the state of the so-called B stage.

In ~~the~~ a case where the anisotropic conductive film forming thermosetting adhesive 6b in ~~the~~ liquid form has a high viscosity, the liquid thermosetting adhesive 6b is applied to a specified position on ~~the~~ board 4 by ~~means~~ use of the dispenser 502 as shown in Fig. 7D, and thereafter, the thermosetting adhesive 6b is spread flat by a squeegee 506 as shown in Figs. 7E and 7F, since the adhesive does not naturally spread on the board due to the high viscosity of the thermosetting adhesive 6b. Subsequently, by putting the board 4 into the furnace 503 by ~~means~~ use of the conveying unit 505, ~~like a conveyer~~ as shown in Fig. 7C, and hardening the liquid thermosetting adhesive 6b ~~of the applied insulating resin by~~ via the heater 504 of the furnace 503, the adhesive is solidified into ~~the~~ a semi-solid state, i.e., the state of the so-called B stage.

As described above, although there is a difference depending on ~~the~~ characteristics of the thermosetting resin in the thermosetting adhesive 6b when the anisotropic conductive film forming thermosetting adhesive 6b is semi-solidified, pressurization is effected at a temperature of 80 to 130°C, which is 30 to 80% of ~~the~~ a glass transition point of the thermosetting resin. The pressurization is normally performed at a temperature of about 30% of the glass transition point of the thermosetting resin. ~~The~~ A reason why the temperature is 30 to 80% of the glass transition point of the thermosetting resin is that a further range for reaction can ~~still sufficiently be left in the~~ remain for subsequent processes within the range of 80 to 130°C, according to ~~the~~ a graph of ~~the~~ heating temperature of the anisotropic conductive film sheet with respect to its reaction rate, as shown in ~~of~~ Fig. 19. In other words, ~~the~~ reaction rate of the insulating resin, or for example, ~~the~~ epoxy resin can be restrained to about 10 to 50%, also depending on time, within the temperature range of 80 to 130°C, and therefore, no problem occurs at ~~the~~ a time of IC chip pressure bonding in ~~the~~ subsequent processes. That is, ~~the~~ a prescribed quantity of pressure can be secured at the time of pressure-bonding the IC chip, and this ~~scarcely incur the~~ rarely incurs a problem in that ~~the~~

press-cutting cannot be performed ~~achieved~~. It is also possible to perform ~~the~~ semi-solidification by vaporizing only ~~the~~ a solvent component while restraining ~~the~~ a reaction.

When a plurality of IC chips 1 are mounted on ~~the~~ board 4 after the thermosetting adhesive 6b is semi-solidified as described above, ~~the~~ productivity is further improved by preliminarily performing the semi-solidifying process of the thermosetting adhesive 6b as a pre-arranging process ~~in~~ at a plurality of portions which belong to the board 4 and ~~in~~ to which the plurality of IC chips 1 are mounted, supplying the thus pre-arranged board 4, and bonding the plurality of IC chips 1 to the plurality of portions of the board 4. In ~~the~~ subsequent processes, even when the thermosetting adhesive 6b is used, ~~the~~ a process basically identical to the process employing the anisotropic conductive film sheet 10 of the aforementioned first or second embodiment is ~~basically~~ performed. By adding the semi-solidifying process, the liquid anisotropic conductive film forming thermosetting adhesive 6b can be employed similarly to the anisotropic conductive film sheet 10, and this arrangement has ~~the~~ an advantage in that ~~the~~ handling is easy because of ~~the~~ solidness and ~~the~~ an advantage in that an adhesive having a high glass transition point can be formed since the adhesive can be formed of polymer because of ~~the~~ non-existence of a liquid component. When the anisotropic conductive film forming thermosetting adhesive 6b having fluidity is employed as described above, there is ~~the coexistent~~ a co-existent advantage in that the adhesive can be applied, ~~or~~ printed or transferred in an arbitrary size to arbitrary positions of the board 4 ~~by comparison with the~~ as opposed to a case where ~~the~~ a solid anisotropic conductive film sheet 10 is employed.

(Fourth Embodiment)

A method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module of, for example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to a fourth embodiment of the present invention will be described next with reference to Fig. 22. The fourth embodiment differs from the first embodiment in that ~~the~~ a bump tip is shaped so as to prevent ~~the~~ short circuit with adjacent bumps or electrodes due to ~~the~~ collapse of a neck (whisker) portion at ~~the~~ a tip of the bump 3, caused by ~~the~~ tearing~~-off~~ at ~~the~~ a time of bump formation, by pressurizing the bump 3 with a load of not greater than 20 gf ~~at need~~ without leveling the bump 3 with supersonic

waves applied in addition to the load when ~~the~~ IC chip 1 is bonded to ~~the~~ board 4. The ~~, the~~ IC chip 1 is thereafter mounted ~~on~~ onto the board 4 while aligning in position the IC chip 1 with the board 4, and ~~the~~ metal bumps 3 are subjected to thermocompression-bonding with supersonic waves to ~~the~~ metals of the electrode surface on the board ~~side~~. ~~The~~ A state in which the IC chip 1 is bonded to the board 4 is similar to those of Fig. 2 and Fig. 6 of the aforementioned embodiments.

When metallically bonding ~~the~~ gold bumps to ~~the~~ electrodes of the board with supersonic waves applied, it is acceptable to apply heat from ~~the~~ an upper surface side of the IC chip 1 or from the board side, or from both the IC chip 1 side and the board side.

According to this fourth embodiment, ~~the~~ solid anisotropic conductive film sheet 10 or ~~the~~ a liquid anisotropic conductive film forming thermosetting adhesive 6b semi-solidified as described above, obtained by mixing ~~the~~ insulating thermosetting resin 6m with ~~the~~ inorganic filler 6f, is ~~stuck~~ adhered to the board 4, or the anisotropic conductive film forming thermosetting adhesive 6b that contains the thermosetting resin is applied to the board 4 and semi-solidified. Thereafter, ~~the~~ ball 96 is formed by applying an electric spark ~~at the~~ to a tip of ~~the~~ gold wire 95 through the operation as shown in Fig. 3A through Fig. 3F, similar ~~similarly~~ to ~~the~~ wire bonding of ~~the~~ electrodes 5 of the board 4 and ~~the~~ electrodes 2 of the IC chip 1, and the IC chip 1 is mounted ~~on~~ onto the board 4 by aligning in position the bumps 3, each of which is formed by thermocompression-bonding this ball 96 to ~~the~~ a board electrode 5 with supersonic waves by ~~means~~ virtue of ~~the~~ capillary 93, ~~with the IC chip 1~~ without leveling the bumps 3. In this case, the aforementioned "~~the~~ liquid anisotropic conductive film forming thermosetting adhesive 6b semi-solidified as described above" is ~~the~~ an object obtained by semi-solidifying the liquid anisotropic conductive film forming thermosetting adhesive 6b as described in connection with the third embodiment, approximately similar to ~~the~~ an object put in the B stage. At this time, in a supersonic wave applying device 620 as shown in Fig. 22, ~~the~~ gold bumps 3 are metallically bonded to ~~the~~ gold plating located on ~~the~~ board ~~side~~ 4 while shaping ~~the~~ tips of the bump so as to prevent ~~the~~ collapse of neck portions at ~~the~~ tips of the gold bumps 3 by effecting a load of an air cylinder 625 applied from ~~the~~ an upper surface of the IC chip 1, sucked and held by ~~the~~ a pre-heated bonding tool 628 with a built-in heater 622, and ~~the~~ supersonic waves that are generated by a supersonic wave generating element 623 such as a piezoelectric element and applied via a supersonic wave horn 624. Next, the IC chip 1 is pressed against the circuit board 4 with a

pressure force of not smaller than 20 gf per bump while heating the IC chip 1 from the upper surface side of the IC chip 1 and/or from the board side so as to correct ~~the warp~~ warpage of the board 4 and crush the bumps 3, and the anisotropic conductive film sheet 10 or the thermosetting adhesive 6b interposed between the IC chip 1 and the circuit board 4 is hardened by ~~the~~ heat so as to bond the IC chip 1 to the circuit board 4, electrically connecting together both the electrodes 2 and 5 ~~together~~. It is also acceptable to apply heat from the upper surface side of the IC chip 1 or from the board side or from both the IC chip 1 side and the board side at the time of the metallic bonding performed by the supersonic wave applying device 620. That is, in concrete, it is acceptable to apply heat to the IC chip 1 from the upper surface side by the built-in heater 622 or apply heat to the circuit board 4 from the board side by ~~the~~ heater 9a of ~~the~~ stage 9, or apply heat from both the IC chip 1 side and the board side by the built-in heater 622 and the heater 9a of ~~the~~ stage 9.

~~The~~ A reason why ~~the~~ a pressure force of not smaller than 20 gf per bump is needed is that ~~the~~ bonding cannot be achieved since frictional heat ~~scarcely~~ rarely occurs even by ~~the~~ bonding using supersonic waves as described above. Also, when bonding gold to gold ~~together~~, frictional heat is generated by pressing the bump with a specified constant load and applying supersonic waves to ~~the~~ a portion of the bump, by which the metals are bonded together. Therefore, even in this case, ~~the~~ a specified load sufficient for pressurizing the bump, i.e., ~~the~~ a pressure force of not smaller than 20 gf per bump is needed. For example, the pressure force is set to 50 gf or more per bump.

According to the fourth embodiment, the metal bumps 3 and the metal plating of the board 4 are subjected to metallic diffusion bonding, and this arrangement is therefore appropriate for giving a strength to each bump portion, or further reducing ~~the~~ a connection resistance value.

(Fifth Embodiment)

A method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted ~~on~~ onto the board by the mounting method, according to a fifth embodiment of the present invention will be described next with reference to Fig. 8A through Fig. 8C and Fig. 9A through Fig. 9C. The fifth embodiment differs from the first embodiment in that ~~the~~ an encapsulation process can be eliminated.

As described above, ~~the~~ protruding electrodes (bumps) 3 are preparatorily formed on ~~the~~ electrodes 2 of ~~the~~ IC chip 1. On ~~the~~ circuit board 4, as shown in Fig. 8B, Fig. 8C, Fig. 9A and Fig. 23, a rectangular sheet-shaped anisotropic conductive film sheet 10, or a thermosetting adhesive 6b, that has a configurational dimension smaller than an approximately ~~rectangle~~ rectangular-shaped outline dimension OL, defined by joining ~~the~~ inner edges of the ~~plurality of~~ electrodes 2 of the IC chip 1, is preparatorily ~~stuck~~ adhered or applied to a ~~center~~ central portion of a region defined by joining ~~the~~ electrodes 5 of the circuit board 4. At this time, ~~the~~ a thickness of the sheet-shaped anisotropic conductive film sheet 10 or the thermosetting adhesive 6b is set so that its volume becomes slightly greater than a gap between the IC chip 1 and the board 4. By ~~means~~ use of the pressing ~~sticking~~ device 640 of Fig. 23, a rectangular sheet-shaped anisotropic conductive film sheet 656 that is ~~rewound~~ unwound from ~~a rewinding~~ an un-winding roll 644 and wound around a winding roll 643 is cut along a portion, preliminarily provided with a notch 657 by upper and lower cutter blades 641, into a configurational dimension smaller than the approximately ~~rectangle~~ rectangular-shaped outline dimension OL defined by joining the inner edges of the plurality of electrodes 2 of the IC chip 1. The anisotropic conductive film sheet 10 ~~cut in the~~ having this rectangular sheet-like shape is sucked and held by a sticking head 642, which is pre-heated by a built-in heater 646, and adhered ~~stuck to~~ the ~~center~~ central portion of the region defined by joining the electrodes 5 of the circuit board 4. Next, the bumps 3 and the electrodes 5 of the circuit board 4 are aligned in position and, as shown in Fig. 8A and Fig. 9B, the IC chip 1 is pressed ~~pressurized with a pressure~~ against the circuit board 4 by ~~the heating~~ bonding tool 8 which is heated by the heater 8a, so as to concurrently perform ~~the~~ correction of ~~the~~ warp of the board 4 and harden the anisotropic conductive film sheet 10 or the thermosetting adhesive 6b interposed between the IC chip 1 and the circuit board 4. At this time, the anisotropic conductive film sheet 10 or the thermosetting adhesive 6b is softened as described hereinabove, by ~~the~~ heat applied from the bonding tool 8 via the IC chip 1, and flows ~~outward~~ outwardly by being pressurized from ~~the~~ a position to which it has been adhered ~~stuck~~ or applied, as shown in Fig. 9C. This outflow anisotropic conductive film sheet 10 or thermosetting adhesive 6b becomes an encapsulation material (underfill), which remarkably improves ~~the~~ reliability of ~~the~~ bonding of the bumps 3 to the electrodes 5. After a lapse of a specified time, ~~the~~ hardening of the anisotropic conductive film sheet 10 or the thermosetting adhesive 6b gradually progresses, and ~~the~~ hardened

resin 6s finally bonds the IC chip 1 to the circuit board 4. By moving ~~up~~ upwardly the bonding tool 8, that is pressurizing the IC chip 1, ~~the~~ bonding of the IC chip 1 to the electrodes 5 of the circuit board 4 is completed. Strictly speaking, in ~~the~~ a case of thermosetting resin, ~~the~~ reaction of the thermosetting resin progresses during heating, and ~~the~~ fluidity almost disappears with ~~the~~ a moving-up motion of the bonding tool 8. According to the above-mentioned method, neither the anisotropic conductive film sheet 10 nor the thermosetting adhesive 6b covers the electrodes 5 before bonding, and therefore, the bumps 3 are brought ~~in~~ into direct contact with the electrodes 5 at ~~the~~ a time of bonding. Then, neither the anisotropic conductive film sheet 10 nor the thermosetting adhesive 6b enters spaces under the electrodes 5, and ~~the~~ a value of connection resistance between ~~the~~ each bump 3 and ~~the~~ its corresponding electrode 5 can be reduced. If the circuit board ~~side~~ is heated, then ~~the~~ a temperature of the bonding head 8 can ~~further~~ be reduced. If this method is applied to the third embodiment, ~~the~~ bonding of ~~the~~ gold bumps to ~~the~~ gold electrodes (for example, copper or tungsten plated with nickel or gold) of the circuit board can easily be achieved.

(Sixth Embodiment)

A method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip on a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted ~~on~~ onto the board by the mounting method, according to a sixth embodiment of the present invention will be described next with reference to Fig. 10A through Fig. 10D and Fig. 11A through Fig. 11E. The sixth embodiment differs from the first embodiment in that high-reliability bonding can be achieved even if a bump 103 is mounted on ~~the~~ electrode 5 of ~~the~~ circuit board 4 while being shifted.

According to the sixth embodiment, as shown in Fig. 10A, a gold ball ~~96~~ is formed ~~of~~ from a gold wire 95 by subjecting the wire to an electric spark ~~similarly to the wire bonding in forming the bump 3 on the IC chip 1~~. Next, a ball 96a of a diameter Φd-Bump denoted by 95a is formed while adjusting ~~the~~ a size of the ball by ~~the~~ duration of application of the electric spark, and the thus-formed ball 96a ~~of the~~ having diameter Φd-Bump is formed by controlling ~~the~~ a parameter of time or voltage for generating the electric spark so that a chamfer diameter φD denoted by 93a of a capillary 193, whose chamfer angle θc is not greater than 100°, becomes one-half to three-fourths the gold ball

diameter Φd-Bump. Instead of forming a bump 3 as shown in Fig. 10D via ~~with the~~ provision of a flat portion 93b in ~~the~~ a portion of the capillary that is to be brought ~~in~~ into contact with the gold ball ~~of the capillary 93~~ as shown in Fig. 10C, a bump 103 as shown in Fig. 10B is formed on ~~the~~ electrode 2 of ~~the~~ IC chip 1 by performing supersonic wave thermocompression-bonding via ~~by means of a~~ capillary 193 whose ~~tip shape has a~~ tip portion 193a is provided with ~~no~~ a non-flat shape, which tip ~~portion in the~~ portion is to be brought ~~in~~ into contact with the gold ball 96a ~~of the capillary 193~~ as shown in Fig. 10A. By using ~~the~~ capillary 193 having the above-mentioned ~~tip~~ shape, an approximately conically tipped bump 103 as shown in Fig. 10B can be formed on the electrode 2 of the IC chip 1. Even when the approximately conically tipped bump 103 formed by the above-mentioned method is mounted on ~~the~~ electrode 5 of ~~the~~ circuit board 4 while being shifted as shown in Fig. 11C, the bump 103 can be partially brought ~~in~~ into contact with the electrode 5 of the board 4 without fail since the bump 103 has the approximately conically shaped tip, so long as the bump is not shifted by more ~~shift is not greater~~ than half ~~the~~ an outside diameter of the bump 103.

In contrast to this, in ~~the~~ a case of a bump 3 as shown in Fig. 11D, when the bump 3 is mounted on ~~the~~ electrode 5 of ~~the~~ circuit board 4 while being shifted by a dimension Z as shown in Fig. 11C, ~~the~~ a so-called base 3g of a width dimension d partially comes ~~in~~ into contact with the electrode 5 as shown in Fig. 11E. However, this contact is mere partial contact, leading to bonding in an unstable contact state. If the board 4 exhibiting this unstable bonding state is subjected to a thermal shock test or reflow ~~in the above unstable bonding state~~, then ~~the~~ a bond ~~bonding in the unstable bonding state~~ may become broken ~~result in becoming open,~~ and ~~that is,~~ defective ~~bonding~~. In contrast to this, according to the sixth embodiment, even when the approximately conically tipped bump 103 is mounted on the electrode 5 of the circuit board 4 while being shifted by the dimension Z as shown in Fig. 11C, the bump 103 can partially come ~~in~~ into contact with the electrode 5 of the board 4 without fail so long as ~~the shift~~ dimension Z is not greater than half ~~the~~ an outside diameter of the bump 103, since the bump 103 has the conical tip shape, and this can prevent ~~the~~ a possible occurrence of ~~the~~ defective bonding even when the board is subjected to ~~the~~ a thermal shock test or reflow.

(Seventh Embodiment)

A method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to a seventh embodiment of the present invention will be described next with reference to Fig. 12A through 12D and Fig. 13. According to this seventh embodiment, ~~the~~ stress of the IC chip 1 and the circuit board 4 in the first embodiment can be alleviated when the thermosetting resin is hardened after ~~the~~ bonding of the IC chip 1 to the circuit board 4.

In the seventh embodiment, the bump 3 formed on the electrode 2 of the IC chip 1 ~~by the wire bonding~~ is aligned in position with the electrode 5 of the circuit board 4, without leveling the bump, with interposition of a solid or semi-solid anisotropic conductive film sheet 10 or a thermosetting adhesive 6b obtained by mixing an insulating resin 6m with an inorganic filler 6f. The IC chip 1 is pressed against the circuit board 4 with a pressure force P1 of not smaller than 80 gf per bump in ~~the~~ a case of a ceramic board while heating the IC chip 1 from its rear surface side by ~~the~~ tool 8 heated to a specified temperature of, for example, about 230°C to correct ~~the~~ warp of the board 4, and the anisotropic conductive film sheet 10 or the thermosetting adhesive 6b interposed between the IC chip 1 and the circuit board 4 is hardened by ~~the~~ heat. Next, assuming that ~~the~~ a total pressing time is, for example, 20 seconds, then, after a lapse of a specified time t1, i.e., after a lapse of five to ~~10~~ ten seconds (~~being~~ one-fourth ~~or~~ to one-half the total pressing time), also depending on ~~the~~ a reaction rate of ~~the~~ material, or in other words, before the reaction rate of the material reaches 90%, the pressure force applied by the tool is reduced to a pressure P2, which is lower than ~~the~~ pressure P1, to alleviate ~~the~~ stress when the thermosetting adhesive 6b is hardened, and the IC chip 1 and the circuit board 4 are bonded together to electrically ~~connect~~ interconnect both ~~the~~ electrodes 2 and 5. Preferably, by setting ~~the~~ pressure P1 to 20 gf or more per bump for ~~the~~ a reason that a minimum of about 20 gf is required for ~~the~~ deformation of the bump, i.e., in order to obtain ~~the~~ a pressure required for ~~the~~ deformation and adaptation of the bump and force out ~~the~~ excessive resin from between the IC chip 1 and the board 4, and setting ~~the~~ pressure P2 to less than 20 gf per bump in order to remove ~~the~~ hardening distortion unevenly distributed inside the resin before ~~the~~ deformation ~~or the like~~ of the bump, ~~the~~ reliability is improved. ~~The detailed~~ Detailed reasons are as follows. ~~That is, the~~ A stress

distribution of ~~the~~ thermosetting resin in the anisotropic conductive film sheet 10 or the thermosetting adhesive 6b is increased on the IC chip 1 side and the board 4 side at ~~the~~ a time of pressure bonding as shown in Fig. 12C.

In this maintained state ~~kept intact~~, if fatigue is repetitively given through a reliability test and normal long-term use, then the thermosetting resin in the anisotropic conductive film sheet 10 or the thermosetting adhesive 6b is sometimes unable to endure ~~the~~ stress and may separate ~~on~~ from the IC chip 1 ~~side~~ or the board 4 ~~side~~. If the above state occurs, then ~~the~~ adhesive strength of the IC chip 1 and the circuit board 4 becomes insufficient and ~~the~~ a bonded portion becomes open. Accordingly, by adopting a two-step pressure profile of ~~the~~ higher pressure P1 and ~~the~~ lower pressure P2 as shown in Fig. 13, ~~the~~ pressure can be reduced to ~~the~~ pressure P2, lower than ~~the~~ pressure P1, when the thermosetting adhesive 6b is hardened, and ~~the~~ stress of the IC chip 1 and the circuit board 4 can be alleviated (in other words, ~~the~~ a degree of stress concentration can be reduced), as shown in Fig. 12D, by removing ~~the~~ a hardening distortion unevenly distributed inside the resin with ~~the~~ pressure P2. Subsequently, by increasing ~~the~~ pressure to ~~the~~ pressure P1, a pressure required for ~~the~~ deformation and adaptation of ~~the~~ a bump can be obtained, and ~~the~~ excessive resin can be forced out of ~~the~~ a space between the IC chip 1 and the board 4, thereby improving ~~the~~ reliability.

It is to be noted that the aforementioned "adhesive strength of the IC chip 1 and the circuit board 4" means a force to make the IC chip 1 and the board 4 adhere to each other. ~~With~~ In this regard, the IC chip 1 and the board 4 are bonded together by ~~the~~ three forces: (1) ~~of~~ an adhesive strength provided by the adhesive~~,~~ ; (2) a hardening shrinkage force when the adhesive is hardened~~,~~ ; and (3) a shrinkage force (for example, a shrinkage force generated when the adhesive heated to a temperature of, for example, 180°C shrinks when returning to ~~the~~ normal temperature) in ~~the~~ a Z-direction.

(Eighth Embodiment)

A method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to an eighth embodiment of the present invention will be described next with reference to Fig. ~~12~~ 24A and Fig.

~~13~~ 24B. According to this eighth embodiment, the inorganic filler 6f mixed with the insulating resin 6m in each of the aforementioned embodiments has a mean particle diameter of not smaller than 3 μm. It is to be noted that ~~the~~ a maximum mean particle diameter of the inorganic filler 6f is assumed to have a dimension that does not exceed ~~the~~ a gap dimension between ~~the~~ IC chip 1 and ~~the~~ board 4 after bonding.

If fine particles having a mean particle diameter smaller than 3 μm are used as the inorganic filler 6f when the insulating resin 6m is mixed with the inorganic filler 6f, then ~~the~~ a surface area of those particles becomes large as a whole, and this possibly leads to moisture absorption ~~to the~~ in a periphery of the inorganic filler 6f ~~of the particles that have~~ having a mean particle diameter smaller than 3 μm, which is disadvantageous in terms of ~~the~~ bonding of the IC chip 1 to the board 4.

Therefore, when the inorganic filler 6f of the same weight is mixed, ~~the~~ an amount of moisture absorption ~~to~~ in a ~~the~~ periphery of the inorganic filler 6f can be reduced by employing ~~a larger~~ an inorganic filler 6f that has a mean particle diameter of not smaller than 3 μm, and this allows ~~the~~ moisture resistance to be improved. Moreover, the inorganic filler of a larger mean particle diameter (in other words, average grain size) is generally less expensive, and this is preferable in terms of cost.

As shown in Fig. 24A, according to ~~the~~ a processing method that employs ~~the~~ conventional ACF (Anisotropic Conductive Film) 598 for ~~the~~ bonding of ~~the~~ IC chip 1 to ~~the~~ board 4, it is required to place conductive particles 599 in the ACF 598 between ~~the~~ bump 3 and ~~the~~ board electrode 5 without fail, and concurrently effect ~~the~~ conductivity by crushing the conductive particles ~~of~~ from a diameter of 3 to 5 μm to a diameter of 1 to 3 μm. However, in each of the aforementioned embodiments of the present invention, the conductive particles 10a, which may exist, are not necessarily ~~be~~ placed between ~~the~~ bump 3 and ~~the~~ board electrode 5. As shown in Fig. 24B, the bump 3 is pressure-bonded to ~~the~~ board electrode 5 while being crushed, and therefore, ~~the~~ inorganic filler 6f also slips out of ~~the~~ a space between the bump 3 and the board electrode ~~4~~ 5 together with ~~the~~ anisotropic conductive layer 10 located between the bump 3 and the board electrode ~~4~~ 5 at ~~the~~ a time of this pressure bonding. ~~On the basis of the feature that~~ Because almost no hindrance of conductivity occurs due to ~~the~~ placement of ~~the~~ unnecessary inorganic filler 6f between the board electrode ~~4~~ 5 and the bump 3, the inorganic filler 6f that has a large mean particle diameter of not smaller than 3 μm can be employed. That is, according to the present embodiment, even if ~~the~~

conductive particles 10a are not placed between the bump 3 and the board electrode 5 by ~~any~~ chance, and ~~the~~ conductivity is not effected by ~~the~~ crushing of the conductive particles ~~that have~~ from a diameter of 3 to 5 μm to a diameter of 1 to 3 μm, ~~the~~ electrical conductivity is obtained by ~~the~~ direct electrical contact of the bump 3 with the board electrode 5 by virtue of ~~the~~ crushing of the bump 3 by the board electrode 5. Accordingly, there is no problem, and ~~the~~ reliability can be improved without receiving ~~the~~ influence of the inorganic filler. That is, there is produced ~~the~~ an additional effect that the conductive particles 10a can reduce ~~the~~ a value of the connection resistance between ~~the~~ board electrode 5 located on the board ~~side~~ and ~~the~~ bump 3 located on the IC chip ~~side~~ when placed between the bump 3 and the board electrode 5 through ~~the~~ direct bonding of the bump 3 to the board electrode 5.

(Ninth Embodiment)

A method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to a ninth embodiment of the present invention will be described next with reference to Fig. 25 and Fig. 26. Fig. 25 and Fig. 26 are a schematic sectional view of a bonded state produced by the method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and a partially enlarged schematic sectional view of an anisotropic conductive film sheet 10 employed in this method and apparatus ~~the above case~~, according to the ninth embodiment. According to this ninth embodiment, the inorganic filler 6f to be mixed with the insulating resin 6m of the anisotropic conductive layer 10 in each of the aforementioned embodiments ~~is provided by~~ includes inorganic fillers 6f-1 and 6f-2, which have a plurality of different mean particle diameters. As a concrete example, an inorganic filler having a mean particle diameter of 0.5 μm and an inorganic filler having a mean particle diameter of 2 to 4 μm are employed.

According to the ninth embodiment, by mixing the insulating resin 6m with the inorganic fillers 6f-1 and 6f-2, which have the plurality of different mean particle diameters, ~~the~~ an amount of the inorganic filler 6f to be mixed with the insulating resin 6m can be increased, and ~~the~~ an amount of moisture absorption ~~to the~~ in a periphery of the inorganic filler can be reduced. This enables ~~the~~

improvement in ~~the~~ terms of moisture resistance and facilitates ~~the~~ film formation (solidification). That is, in terms of percentage by weight, ~~the~~ an amount of the inorganic filler per unit volume can be increased when inorganic fillers of different particle diameters are mixed ~~rather than~~ as opposed to when one type of inorganic filler is employed. This enables ~~the~~ an increase in amount of the inorganic filler 6f to be ~~mixed with~~ part of the anisotropic conductive film sheet 10 or ~~the~~ anisotropic conductive film forming thermosetting adhesive 6b, that serves as an encapsulation sheet and enables ~~the~~ reduction in ~~the~~ a coefficient of linear expansion of the anisotropic conductive film sheet 10 or the anisotropic conductive film forming thermosetting adhesive 6b, thereby allowing ~~the~~ an operating life to be increased for ~~the~~ improvement of reliability.

(Tenth Embodiment)

Next, according to a method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to a tenth embodiment of the present invention~~,~~ will be described. In ~~in~~ order to further ensure ~~the~~ an effect of the ninth embodiment, ~~the~~ a mean particle diameter of one inorganic filler 6f-1, of the inorganic fillers 6f-1 and 6f-2, ~~which have the plurality of different mean particle diameters,~~ is two or more times different from ~~the~~ a mean particle diameter of the other inorganic filler 6f-2. As a concrete example, an inorganic filler having a mean particle diameter of 0.5 μm and an inorganic filler having a mean particle diameter of 2 to 4 μm are employed.

With this arrangement, the effect of the ninth embodiment can further be improved. That is, by mixing ~~the~~ insulating resin 6m with ~~the~~ inorganic fillers 6f-1 and 6f-2, which have the plurality of different mean particle diameters, and in which the mean particle diameter of ~~one~~ inorganic filler 6f-1 is two or more times different from the mean particle diameter of ~~the other~~ inorganic filler 6f-2, ~~the~~ an amount of the inorganic filler 6f to be mixed with the insulating resin 6m can be more reliably increased. This arrangement facilitates ~~the~~ film formation (solidification), increases ~~the~~ loadings (mixed amount) of the inorganic filler 6f in the anisotropic conductive film sheet 10 or the anisotropic conductive film forming adhesive 6b, and enables ~~the~~ further reduction in the coefficient of linear

expansion of the anisotropic conductive film sheet 10 or the anisotropic conductive film forming adhesive 6b, thereby allowing the operating life to be increased for further improvement of reliability.

(Eleventh Embodiment)

Next, according to a method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to an eleventh embodiment of the present invention~~, in~~ will be described. In order to further ensure ~~the~~ an effect of the ninth embodiment, it is preferable to ~~provide~~ have the inorganic filler 6f, to be mixed with the insulating resin 6m, include ~~by~~ at least two types of inorganic fillers 6f-1 and 6f-2, which have a plurality of different mean particle diameters, ~~make~~ with one inorganic filler 6f-1 ~~out of at least two types of inorganic fillers have~~ having a mean particle diameter exceeding 3 μm and ~~make~~ the other inorganic filler 6f-2 ~~out of at least two types of inorganic fillers have~~ having a mean particle diameter of not greater than 3 μm. As a concrete example, an inorganic filler having a mean particle diameter of 0.5 μm and an inorganic filler having a mean particle diameter of 2 to 4 μm are employed.

(Twelfth Embodiment)

Next, according to a method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to a twelfth embodiment of the present invention~~, based~~ will be described. Based on each of the aforementioned embodiments, it is acceptable to ~~provide~~ have the inorganic filler 6f, to be mixed with the insulating resin 6m, include ~~by~~ at least two types of inorganic fillers 6f-1 and 6f-2, which have ~~a plurality of~~ different mean particle diameters, and constitute ~~one~~ inorganic filler 6f-1, having ~~of~~ the larger mean particle diameter, ~~out of at least two types of inorganic fillers by~~ from a material identical to that of the insulating resin 6m, thereby producing a stress alleviating effect. As a concrete example, an inorganic filler having a mean particle diameter of 0.5 μm and an inorganic filler having a mean particle diameter of 2 to 4 μm are employed.

According to this twelfth embodiment, ~~the~~ a stress alleviating effect can be produced, in addition to ~~the~~ an operative effect of the ninth embodiment, by virtue of ~~the~~ an arrangement that the ~~one~~ inorganic filler 6f-1 having ~~of~~ the larger mean particle diameter is made of the material identical to that of the insulating resin 6m, and ~~the~~ integration of the inorganic filler 6f-1 ~~of the larger mean particle diameter~~ with the insulating resin 6m when a stress is exerted on the insulating resin 6m.

(Thirteenth Embodiment)

Next, according to a method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to a thirteenth embodiment of the present invention~~, based~~ will be described. Based on each of the aforementioned embodiments, it is acceptable to ~~provide~~ have the inorganic filler 6f, to be mixed with the insulating resin 6m, include ~~by~~ at least two types of inorganic fillers 6f-1 and 6f-2, which have ~~a plurality of~~ different mean particle diameters, and make ~~one~~ inorganic filler 6f-1 ~~of~~ having the larger mean particle diameter ~~out of at least two types of inorganic fillers~~ softer than ~~the~~ an epoxy resin of the insulating resin 6m, thereby producing a stress alleviating effect by ~~the~~ compression of the ~~one~~ inorganic filler 6f-1.

According to this thirteenth embodiment, the stress alleviating effect can be produced, in addition to the operative effect of the ninth embodiment, by virtue of ~~the~~ an arrangement that the inorganic filler 6f-1 ~~of~~ having the larger mean particle diameter is made of the material identical to that of the insulating resin 6m, and ~~the~~ an arrangement that the inorganic filler 6f-1 ~~of the larger mean particle diameter~~ is softer than the epoxy resin of the insulating resin 6m~~, as~~ . As a consequence, ~~of which~~ the ~~one~~ inorganic filler 6f-1 is compressed as shown in Fig. 27 to disperse ~~the~~ a tension force, of a reactive force against ~~the~~ compression, therearound ~~around there~~ when a stress is exerted on the insulating resin 6m.

(Fourteenth Embodiment)

Next, according to a method and apparatus for mounting an electronic component ~~of~~, for example, an IC chip ~~on~~ onto a circuit board, and an electronic component unit or module ~~of~~, for

example, a semiconductor device in which the IC chip is mounted on the board by the mounting method, according to a fourteenth embodiment of the present invention~~, based~~ will be described. Based on each of the aforementioned embodiments, it is further acceptable to ~~mix~~ provide a portion 700 or a layer 6x, which belongs to ~~the~~ anisotropic conductive layer 10 and is brought ~~in~~ into contact with ~~the~~ IC chip 1 or ~~the~~ board 4, with a smaller amount of inorganic filler than another portion 701 or a layer 6y, or with no inorganic filler ~~6f~~, as shown in Figs. 28A and 28B, Figs. 29A and 29B, Fig. 30 and Fig. 31. In this case, it is acceptable to gradually vary ~~the~~ an amount of inorganic filler without definitely distinguishing the portion 700 brought ~~in~~ into contact with the IC chip 1 or the board 4 from the other portion 701, as shown in Fig. 28A and 28B, or to definitely distinguish them from each other as shown in Figs. 29A and 29B, Fig. 30 and Fig. 31. That is, in Figs. 29A and 29B, Fig. 30 and Fig. 31, the anisotropic conductive layer 10 is of a ~~allowed to have~~ a multilayer structure provided with a first resin layer 6x that is positioned in ~~the~~ a portion brought ~~in~~ into contact with the IC chip 1 or the board 4, and in which an insulating resin, identical to the insulating resin 6m, is mixed with the inorganic filler 6f, as well as a second resin layer 6y constructed of the insulating resin mixed with a smaller amount of inorganic filler than the first resin layer 6x, or with no inorganic filler 6f.

Please replace the original abstract with the enclosed substitute abstract.

ABSTRACT OF THE DISCLOSURE

A chip is bonded on a circuit board by aligning in position bumps ~~3~~ with board electrodes ~~5~~ with interposition of an anisotropic conductive layer ~~10 in which~~ between the chip and the circuit board. The anisotropic conductive layer is a mixture of an insulating resin, ~~is mixed with~~ conductive particles ~~10a~~ and an inorganic filler. ~~6f, and pressing the~~ The chip ~~1~~ is pressed against the board ~~4~~ with a pressure force of not smaller than 20 gf per bump ~~applied to the chip 1 against the board 4~~ by ~~means~~ virtue of a tool, ~~head 8~~ while ~~correcting~~ warp of the chip and the board is corrected, ~~and crushing~~ the bumps are compressed, and ~~hardening~~ the insulating resin is hardened.